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Spruce Budworm

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PRELIMINARY REPORT ON THE 1953 SPRUCE BUDWORM BIOLOGICAL STUDIES IN OREGON

by

P. W. ORR

Submitted in partial fulfillment of the requirements of the University of Washington, College of Forestry senior spring field trip of 1953.

TABLE OF CONTENTS

PAGE

FOREWORD

INTRODUCTION 1

REVIEW OF NATURAL CONTROL FACTORS 2
Insect Parasites and Predators 2
Weather Conditions. 2
Bird and Animal Predators 3
Disease 3
Unknown causes 3

SUMMARY OF PREVIOUS WORK 4

CURRENT STUDIES 5
Objectives 5
Procedures Used 5
Timing the Sample 5
Selecting the Sample 6
Methods of Sampling on Unsprayed Areas 6
Methods of Sampling on Sprayed Areas 6

RESULTS OF THE 1953 SURVEYS 7
Natural Control on Unsprayed Areas 7
Natural Control on Sprayed Areas 8

ASSOCIATED LEPIDOPTEROUS SPECIES 8

SUMMARY 10

LITERATURE CITED 11

APPENDIX

Table I. Summary of Spruce Budworm Populations and Parasitism on sprayed areas in Oregon, 1951-1953 . 12
Table II. Egg Survey, Ochoco Area 13
Table III. Primary Budworm Parasites . . . . . 14 and 15
Table IV. Population Reduction During Overwintering Stage, Ochoco Area, 1952-1953 16
Plate I. Location of Study Areas 17
Plate II. Parasites Attacking Mature Larvae and Pupae of the Budworm 18

FOREWORD

In April, 1953, by informal agreement between the University of Washington, College of Forestry and the Bureau of Entomology and Plant Quarantine, the writer was appointed Cooperative Agent to assist Mr. W. K. Coulter in his biological studies of the spruce budworm in Oregon and Washington. These studies were substituted for the regular senior spring field trip taken by forest management majors at the College of Forestry.

An agreement such as this gives the student of forestry and forest entomology a first-hand view of the diverse problems facing the research worker in the field of forest entomology here in the Pacific Northwest. It is of benefit to both cooperating agencies in that it provides the Bureau with technically trained foresters early in the spring when seasonal help is usually unavailable and it provides the student with practical "on-the-job" training. The writer feels that this arrangement gives invaluable instruction to the student training for the field of forest entomology and should be encouraged whenever possible.

The writer wishes to express his appreciation to Mr. R. L. Furniss, Entomologist in Charge, Portland Forest Insect Laboratory, and to Dean Gordon D. Marckworth and Dr. J. C. H. Robertson of the College of Forestry without whose help this progressive step in forestry training could not have been accomplished. Special recognition is due Mr. W. K. Coulter, of the Bureau, who directed the cooperative field work.

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INTRODUCTION

For many years the spruce budworm, Choristoneura fumiferana (Clem.), has been an endemic resident of the Pacific Northwest coniferous forests rarely causing extensive damage to the timber stands. Minor outbreaks of this insect pest were recorded in 1921, 1929, 1931 and from 1941 to 1944. These attacks were of a very local nature and caused no great alarm throughout the region as a whole. In 1948, however, the normally endemic population increased into epidemic proportions threatening valuable timber resources over sufficiently wide-spread areas to justify the expense involved in its control by aerial spraying with DDT compounds.

A long-term insect control program cannot be efficient without a thorough knowledge of the life cycle, parasites, predators, and habits of the pest. It is with this in mind that in 1950, the Bureau of Entomology and Plant Quarantine initiated long-term studies of the spruce budworm and its natural control factors. Since that time, annual studies have been conducted to learn more of the biology of this destructive insect pest of Northwest forests.

A summary of previous work on the biology of the budworm is included in this report covering the period from 1948 to 1952. This material shows the trend in the biological studies on this destructive pest.

This report covers the immature larvae survey on old sprayed areas and the egg and overwintering larvae survey on unsprayed areas as outlined by Coulter in 1953 (3) 1/. This plan follows closely the one initiated by Carolin in 1950 (1) and continued by Carolin and Wright (2) in 1951. The results of the immature larvae, mature larvae, and pupae survey on unsprayed areas in Oregon will be reported later when the data have been collected and analyzed. The length of the writer's assignment to this project does not permit their inclusion in this report.

1/ Numbers in parenthesis refer to Literature Cited page 11

REVIEW OF NATURAL CONTROL FACTORS

The causes of mortality in spruce budworm populations may be traced to one or more of the following categories:

1. Mortality due to insect parasitism and predation and bird and animal predation.

2. Mortality due to adverse weather conditions, particularly during the time of larval migration to and from hibernation.

3. Mortality due to virus, bacterial or fungus diseases.

4. Mortality due to unknown natural control factors.

Insect Parasites and Predators

Marked declines in spruce budworm populations in the East have been attributed directly to the effect of insect parasitism. In the Northwest, however, the originally expected natural control of the budworm by parasites has fallen below the anticipated level in epidemic populations. On the other hand, low-level residual budworm populations on old sprayed areas have been found to be rather heavily parasitized. The heavy parasitism on these areas may be due, in part, to the reinfestation of the sprayed areas by small, wind-blown budworm larvae together with their parasites. On the unsprayed areas, parasites continue to exert a low but significant degree of natural control and should not be discounted in considering the total natural control.

Plate I illustrates the adult form of the three main parasites of the budworm in Oregon and Washington during the period 1948 to 1952. Table III summarizes the known parasites of the budworm and the developmental stages during which they attack and emerge. Several new parasites must be studied further before their inclusion in this list.

Weather Conditions

Overwintering mortality occurs in budworm populations due to the affect of adverse weather conditions particularly during the time the larvae migrate to and from their places of hibernation. During these migrations the larvae are in an exposed positions on the foliage and twigs. In such positions, they are susceptible to the ravages of driving rains and cold lethal temperatures. Severe winds during this stage of larval development may knock many small larvae from the twigs and branches and thus make them susceptible to one or more of the other major causes of budworm mortality.

Bird and Animal Predators

Dowden et al. (5) found indications that the resident bird population consumed between 100 and 300 spruce budworm larvae per tree during the 1950 studies on a budworm outbreak in northern Maine. These figures are probably low since they fail to consider the natural control exerted by transient bird populations such as grosbeaks, finches, and waxwings.

An overall 39 percent reduction in the extensive 1923 spruce budworm outbreak in British Columbia was reported due to insectivorous birds by Tothill (6). This indicates the importance of birds over large areas in the natural control of spruce budworm outbreaks.

Since past experience has shown the effectiveness of insectivorous birds as natural control factors of spruce budworm populations in the East and British Columbia, more intensive study of these agencies seems justified here in the Northwest.

Disease

During the short time these studies have been underway, little mortality due to disease has been observed. In the East, Dowden found a fairly high percentage of the budworm pupae contained the typical polyhedral bodies characteristic of a virus disease. In this same area in the Adirondacks, two mature larvae showed signs of fungus contamination of a secondary nature, while immature larvae showed signs of a typical virus disease. Pathological disease was found in the budworm population around the Barkersville area of British Columbia by Mathers in 1932.

Unknown Causes

In Oregon the budworm populations in certain areas fluctuate from year to year without regularity. At certain times only a small part of these population fluctuations can be attributed directly to the known causes of budworm mortality such as parasites, predators, insectivorous birds and disease. Other causes of this abnormal mortality might well be lethal chromosome crosses or failure of the egg cases. Another possibility in this respect is the inherent biological weakness of the budworm at the molt and at hatching time.

SUMMARY OF PREVIOUS WORK

C. F. Speers in 1948, conducted preliminary biological studies on the seasonal history and parasitism of the spruce budworm in conjunction with the 1948 experimental spray project at Heppner, Oregon. During these studies he found a high percentage of the budworm population in the Catherine Creek drainage was parasitized by the larvaevorid parasite Ceromasia auricaudata T.T.. Speers indicated that this locality could be used as a collection area from which to obtain a supply of this parasite.

In 1949, as a result of these preliminary studies, W. D. Buchanan collected budworm larvae in the Catherine Creek area to obtain a supply of this parasite Ceromasia auricaudata T.T., and the ichneumonid Phytodietus fumiferanae Rohw. The plan was to ship these parasites to Maine where they would be propogated for release. Few parasites were obtained and the plan failed. Similar results were obtained in 1950 and again in 1951.

V. M. Carolin, of the New Haven Forest Insect Laboratory, initiated the present long-term studies on the biology of the spruce budworm in Oregon and Washington in 1950. The purpose of these studies were to provide a more complete knowledge of the insect's life history and natural control factors. During the 1950 field season sufficient data were gathered to materially aid in the formulation of artificial control program planning for the 1951 control projects.

These studies initiated by Carolin in 1950 were continued by Carolin and Wright in 1951 (3). During this season three permanent study locations were established in the unsprayed areas in eastern Oregon at Chesnimus, Waterman Flat and North Powder. Analysis of the data gathered on these areas during all stages of budworm development indicated an aggregate parasitism of 38.6 percent, 24.3 percent and 37.0 percent, respectively.

During the 1951 field season, twenty permanent study lines were established on eight areas in Oregon and Washington which were sprayed in 1949 and 1950. The location of these plots is shown on Plate I.

In 1952, Coulter (4) found no significant changes in the effectiveness of natural control agencies on the three unsprayed study areas at Chesnimnus, Waterman Flat and North Powder. The aggregate parasitism on the Chesnimnus area was 56.0 percent and 31.1 percent on the North Powder study area. No aggregate parasitism was computed for the Waterman Flat area since it was sprayed at mid-season. A replacement was established for this plot in the spring of 1953. The average aggregate parasitism of 39 percent in 1952 as compared with 33 percent in 1951 indicates that parasites continued to play an important role in the natural control of the spruce budworm in Oregon.

The budworm populations on sprayed areas remained at a low-level during 1952 with one exception at Bear Springs, Mt. Hood National Forest, Oregon. This area was sprayed late in 1949 when a large percentage of the budworm had pupated and, consequently, the spraying was ineffective. The increase in budworm population necessitated aerial spraying again in 1952.

Parasitism continued to play an important part in the control of low-level budworm populations on the eight sprayed areas in Oregon in 1952. The average aggregate parasitism on these areas was 32.0 percent as determined by the 1952 surveys.

CURRENT STUDIES

Objectives

The biological studies were continued with major emphasis on the trends of budworm populations and parasitism on sprayed areas and the natural control factors affecting the budworm on unsprayed areas in Oregon and Washington.

These studies will provide information needed to improve the control measures through a more detailed knowledge of the budworm and its natural control factors. It is hoped that through these studies some means of budworm control will be found to replace the costly aerial spraying methods.

Procedures used

Timing the sample: In order to determine the correct date on which to sample the egg population on unsprayed areas it was first necessary to make certain all adults had emerged from pupation, mated and oviposited. This was done by examination in the field and by isolating the pupae in individual gelatin capsules and examining the rearings each day for adult emergence. The egg survey commenced when the majority of the moths had emerged.

Correct timing of the overwintering larvae survey on both types of areas was determined by caging rough-barked sections of the larger limbs and trunk from representative trees within the sample areas. These sections were placed in tightly-sealed cardboard boxes which had two glass shell vials inserted in one end. The budworm larvae, emerging from hibernation, were attracted to light and crawled into the shell vials where they were recorded and removed each day. Since this was a forced rearing it was necessary to repeat the process several times to assure the observer that all over-wintering larvae had emerged from their hibernaculae. The immature larvae survey was started when no further emergence occurred.

The immature larvae survey was begun when field examination of the unsprayed study plots indicated that the majority of needle-mining larvae had commenced feeding upon the newly opened buds.

Selecting the sample: All samples of branch and twig material were taken from the midcrown level of Douglas fir and white fir. These were preferably taken from the same branch whorl around all sides of the tree. No samples were taken from overtopped trees since past experience has shown these trees support an abnormally high budworm population due to the earlier opening of their buds and the "spin down" of larvae from the larger crowns.

To prevent the fall and subsequent loss of immature and larger mature larvae, a basket was attached to the head of the pole-pruner to catch the falling twig.

Methods of sampling on unsprayed areas: The location of the unsprayed study areas is shown in Plate I. On study lines within these areas the procedure was to remove five complete branches from the sample tree and examine the foliage for old egg cases, overwintering larvae, immature larvae, mature larvae, and pupae. Any larvae found on the foliage were preserved in alcohol for later dissection in the laboratory to record parasitism and identify any associated lepidopterous larvae.

The records were kept separately for 15-inch twigs and branch remainder to obtain additional data on the proportion of the total branch population that can be expected on the 15-inch twigs. Previous studies indicated that the twigs are poor sampling units for egg surveys since 73.5 percent of the egg masses are found on the branch remainder while only 26.5 percent are observed on the 15-inch twigs. This difference in the position of the budworm population is due to photo-positive habit in the later larval stage and a possible photo-negative habit during the egg laying stage.

Methods of sampling on sprayed areas: On sprayed areas the status of the residual budworm populations were determined by examination of ten 15-inch twigs at each of ten collection points located 5 chains apart on compass lines within the study areas. At each collection point the foliage was examined for all stages of budworm development. The mature larvae were hand picked at random at each collection point and preserved for later dissection to determine parasitism on the sprayed areas. The pupae are hand picked on these areas also. This is done when only the parasitism figures are desired while the foliage is beaten for a specified time to dislodge mature larvae for a population determination.

RESULTS OF THE 1953 SURVEYS

The data gathered from these surveys are summarized in Table I for the immature larvae survey on sprayed areas. Table II summarizes the data from the egg survey on the unsprayed study area at Ochoco in central Oregon. Data from the overwintering larvae survey showing population reduction on this same area are summarized in Table IV.

The late start of the 1953 growing season, late bud development on Douglas fir and white fir, and the cold driving rains late in the spring had a noteable affect on the budworm development in both sprayed and unsprayed areas in Oregon. Larvae which would normally be in the late bud-mining stage in the middle of June were found to be emerging from hibernation on the newly established Ochoco Plot. During a normal growing season, these larvae would have been in the late third and early fourth instar by this date.

Rapid development of the budworm occurred the first week of July on the Chesnimnus and North Powder intensive study areas where fifth and sixth instar larvae were observed. This rapid development was a result of normal summer temperatures in these areas.

Natural Control On Unsprayed Areas

Egg Survey: Ochoco Plot. The examination of needles from 50 branches of Douglas fir and white fir on this area yielded a total of 287 old egg masses from the 1952 brood. Since it was impossible to count the number of individual eggs in the old egg masses, Carolin and Wright's average of 45 eggs per mass was used giving an average of 1,291 eggs per collection point. Live larvae failed to issue from 15.2 percent of these eggs. Of this figure, 2.7 percent of the mortality was due to egg parasitism by hymenopteron Trichogramma minutum Riley, while the other 12.5 percent was attributed to natural control factors as yet unknown. It is of interest to note that Carolin found this same percentage of egg parasitism on the Chesnimnus study area in 1950.

Eggs parasitized by Trichogramma minutum Riley are easily recognized by their blackish-brown color and sooty appearance. This parasite generally attacks and kills all of the eggs in any one egg mass but has been observed to kill only part of the mass in some instances. Some egg masses, however, apparently were not parasitized but contained a large number of unopened eggs. These were observed to be light-tan in color due to the presence of an undeveloped larval head capsule within the egg case.

Natural Control On Sprayed Areas

It is of interest to note that 3 and 4 years after spraying on these areas that the residual budworm population remains at low-level intensity as shown in Table I. Also, it should be noted that the parasite population, while low, is continuing to exert considerable natural control over the immature budworm larvae on these old sprayed areas. These figures are of academic interest since they show only a trend in the population and fail to give any quantitative data due to the seasonal fluctuations of a low-level budworm population.

The results of the immature larvae surveys in the Roseburg and Eugene, Oregon areas showed that 12 percent of the larvae at Eugene were parasitized by the ichneumonids Glypta fumiferanae (Vier.) and Campoplex (Horogenes) sp. while no parasitism was observed at Roseburg due to the extremely light budworm population. The parasites were identified in their immature form by dissection of the host larvae.

ASSOCIATED LEPIDOPTEROUS SPECIES

During the course of these studies a number of miscellaneous larvae of lepidoptera have been observed in association with the larvae of the spruce budworm in mining the needles and buds of Douglas fir and white fir. These insects have, for the most part, been previously identified and discussed in the literature. Some, however, remain to be identified and studied in more detail. It is important that this be done in conjunction with the budworm project so that information will be readily available if at any time their control becomes necessary.

It is quite possible that this abundance of host material may sustain the larvaevorid parasite, Ceromasia auricaudata T.T. as well as other parasites through the second seasonal generations here in Oregon and Washington.

On the sprayed areas the most common associated species observed was the larch bud moth, Zeiraphera griseana (Hbn.). In the Bear Springs area on the Mt. Hood National Forest, a species of Zeiraphera was observed to differ from the typical griseana by having a lighter colored head capsule, prothoracic shield and anal shield. The larch budmoth has caused severe damage to white fir stands in Washington recently.

A species of Recurvaria, probably piceaella Kearf., was observed feeding on the foliage of Douglas fir in the vicinity of Springfield, Oregon. On the Ochoco Plot in central Oregon the larvae and pupae of this insect were found in the needles of white fir and occasionally Douglas fir. Since other species of this genus have caused severe damage to forests in the West it is well that we learn more of this insect's biology.

Epinotia meritana Hein., the white fir needle miner, was a common associate of the budworm in the Ochoco area. It was possible to find the larvae of this insect in some needles on each branch of white fir examined. In Bryce Canyon National Park this insect caused severe damage to the white fir stands from 1946 to 1948.

Dioryctria reniculella Grt. and D. abietella (D.&S.)are found in association with the budworm on the Ochoco and Chesnimnus unsprayed areas in Oregon. These twig moths and tip miners cause damage to small plantations where they deform the trees. In older stands this damage is less noticeable and usually assumes a minor role.

Larvae of Neodiprion sp. may be found in most all forests in the Northwest. So far, total defoliation of the trees by any member of this genus has not been observed on either Douglas fir or white fir on the study areas. Larvae of this insect were taken on the old sprayed plots in the Eugene and Roseburg, Oregon areas.

Species of Griselda, Tortrix, Eucordylea and Acleris have been recorded during earlier studies but were not observed during these surveys.

SUMMARY

Biological studies on the spruce budworm in Oregon and Washington were continued during 1953 with major emphasis on natural control factors affecting the budworm on the unsprayed areas and the trends in budworm populations and parasitism on sprayed areas.

The reexamination of areas sprayed three and four years ago indicated that a slight increase in the budworm populations occurred this year on the Roseburg and Eugene areas. These increase are slight and are being kept in check by parasites of the immature budworm larvae and one or more other causes of mortality. The principal parasites of the budworm on these areas were Glypta fumiferanae (Vier.) and Campoplex (Horogenes)sp.

The survey of unsprayed areas in Oregon showed a slight increase in the natural budworm population. Parasitism for these areas has not yet been determined. There are indications, however, that the external budworm parasite Omotoma fumiferanae (Toth.) exerted a considerable degree of natural control over mature larvae on several unsprayed study areas in eastern Oregon.

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TABLE I.

SUMMARY OF SPRUCE BUDWORM POPULATIONS AND PARASITISM ON SPRAYED AREAS IN OREGON 1951 - 1953.

AREA AND PLOT	1951 Brood			1952 Brood			1953 Brood			YEAR SPRAYED
	Total Larvae	Larvae per 15" Twig	Percent Parasitism	Total Larvae	Larvae per 15" Twig	Percent Parasitism	Total Larvae	Larvae per 15" Twig	Percent Parasitism	
ROSEBURG										
Henry Mill	18	.060	27.7	0	0	0	2	.020	0	1950
S&S Mill	5	.016	80.0	1	.011	0	0	0	0	1950
Clover Cr.	1	.006	0	0	0	0	0	0	0	1950
Totals	24	.032	37.0	1	.004	0	2	.010	0	
EUGENE										
Creswell	1	.003	50.0	2	.020	0	2	.022	0	1949
Sodaville	1	.003	0	1	.010	0	9	.090	11.0	1949
Sevay Ranch	1	.003	100.0	2	.020	0	4	.040	0	1949
Kampfer Ranch	1	.003	0	2	.020	50.0	11	.110	18.0	1949
Oakridge	3	.001	0	0	0	0	0	0	0	1949
Totals	7	nil*	nil*	7	.010	14.0	26	.050	12.0	
MC KENZIE BRIDGE										
Frissel Cross.	7	.020	28.5	8	.080	14.3	0	0	0	1949 1/
MT. HOOD										
Wamic	1	.003	0	2	.020	0	1	.010	0	1949
Bear Springs	74	.250	37.5	54	.540	35.2	1	.010	0	1949 1/
Beaver Butte	385	2.570	30.0	402	7.310	31.2	1	.010	0	1949 1/
Totals	460	.941	33.7	458	2.950	32.2	3	.010	0	

* Indicates a larval population of less than .005 per 15-inch twig.
1/ Areas resprayed during the 1952 control projects

TABLE II

1953 SPRUCE BUDWORM BIOLOGICAL STUDIES, EGG SURVEY - OCHOCO STUDY AREA, OREGON

Collection Point	Sample Position	No.15" Twigs	No. of egg Masses	Number Unparasitized	No. parasitized (Trichogramma)	Mortality other than Parasitism	Percent Parasitized	Percent Mortality other	Percent total egg mortality	No. of eggs per coll. point 1/
1	Twig	33	15	14	0	1	0	6.7	31.7	1395
	Remain.		16	12	0	4	0	25.0		
2	Twig	26	10	9	1	0	10.0	0	38.5	1080
	Remain.		14	10	1	3	7.1	21.4		
3	Twig	19	7	6	0	1	0	14.3	24.6	1620
	Remain.		29	29	2	1	6.9	3.4		
4	Twig	18	3	2	0	1	0	33.3	42.4	2115
	Remain.		44	40	0	4	0	9.1		
5	Twig	24	11	11	0	0	0	0	10.3	1800
	Remain.		29	26	0	3	0	10.3		
6	Twig	20	10	8	0	2	0	20.0	38.5	1665
	Remain.		27	22	1	4	3.7	14.8		
7	Twig	33	3	2	0	1	0	33.3	50.0	405
	Remain.		6	5	0	1	0	16.7		
8	Twig	31	8	6	0	2	0	25.0	46.4	990
	Remain.		14	11	0	3	0	21.4		
9	Twig	26	6	4	0	2	0	33.3	49.1	1125
	Remain.		19	16	0	3	0	15.8		
10	Twig	28	3	3	0	0	0	0	23.1	720
	Remain.		13	10	3	0	23.1	0		
TOTALS		258	287 2/	243	8	36	2.7	12.5	15.2 x =	1291

1/ Total eggs per station computed from V. M. Carolin and K. H. Wright's 1953 report of an average of 45 eggs per mass.

2/ 73.5 percent of the egg masses occurred on the branch remainder while 26.5 percent occurred on the 15" twigs.

TABLE III

PRIMARY PARASITES RECOVERED FROM THE SPRUCE BUDWORM IN OREGON, 1949-1951

	Stage Attacked	Stage of Emergence	Abundance
HYMENOPTERA			
Braconidae			
Apanteles fumiferanae Vier.	2d instar larvae	5th instar larvae	abundant
Meteorus species 1/	5th instar larvae	mature larvae	rare
Microbracon sp.	mature larvae	mature larvae	rare
Ichneumonidae			
Campoplex (Horogenes) species	2d instar larvae	5th instar larvae	rare to common
Campoplegine, species unknown	?	mature larvae	rare
Ephialtes ontario (Cress.)	prepupae and pupae	pupae	rare
Glypta fumiferanae (Vier.)	2d instar larvae	5th instar larvae	common
Horogenes cacoeciae (Vier.)	2d instar larvae	mature larvae	rare
Itoplectis obesus (Cush.)	prepupae and pupae	pupae	common
Labrorhychus species	mature larvae	pupae	rare
Phaeogenes hariolus (Cress.)	prepupae and pupae	pupae	rare
Phytodietus fumiferanae Rohw.	mature larvae	mature larvae	common
Scambus alboricta (Cress.)	mature larvae	mature larvae	rare
Chalcidoidea			
Elachertus cacoeciae How.	mature larvae	mature larvae	rare
Trichogramma minutum Riley	eggs	eggs	rare
DIPTERA			
Larvaevoridae			
Actia interrupta Curran	mature larvae	mature larvae	rare, locally common
Aplomya caesar (Ald.)	mature larvae	mature larvae and pupae	rare
Ceromasia auricaudata T.T.	mature larvae	pupae	rare, locally common

(Continued)

TABLE III

PRIMARY PARASITES RECOVERED FROM THE SPRUCE BUDWORM IN OREGON, 1949-1951

	Stage Attacked	Stage of Emergence	Abundance
Lypha setifacies West	mature larvae	mature larvae	common in Cascades
Madremyia saundersii Will.	mature larvae	mature larvae and pupae	rare to common
Omotoma fumiferanae (Toth.)	mature larvae	Pupae	common in eastern Ore.
Phorocera erecta Coq.	mature larvae	pupae	rare
Phorocera incrassata Smith	mature larvae	pupae	rare
Phryxe pecosensis T.T.	mature larvae	mature larvae and pupae	rare
Sarchophagidae			
Agria affinis (Fall.)	mature larvae and pupae	pupae	rare

1/ Species found only by dissection of host material

TABLE IV

POPULATION REDUCTION DURING OVERWINTERING STAGES OCHCCO STUDY AREA, 1952 - 1953. Number of Eggs and larvae per branch. 1/

Collection point	Unparasitized eggs	Young larvae mining buds and needles	Percent reduction
1	234	5	97
2	171	17	90
3	288	19	93
4	378	4	99
5	333	13	96
6	270	4	99
7	63	6	91
8	153	8	95
9	225	17	92
10	117	2	98
TOTALS	2232	95	96

1/ These data are based on limb samples of five branches taken from each collection point for the egg survey and two branches taken from each collection point during the overwintering larvae survey.

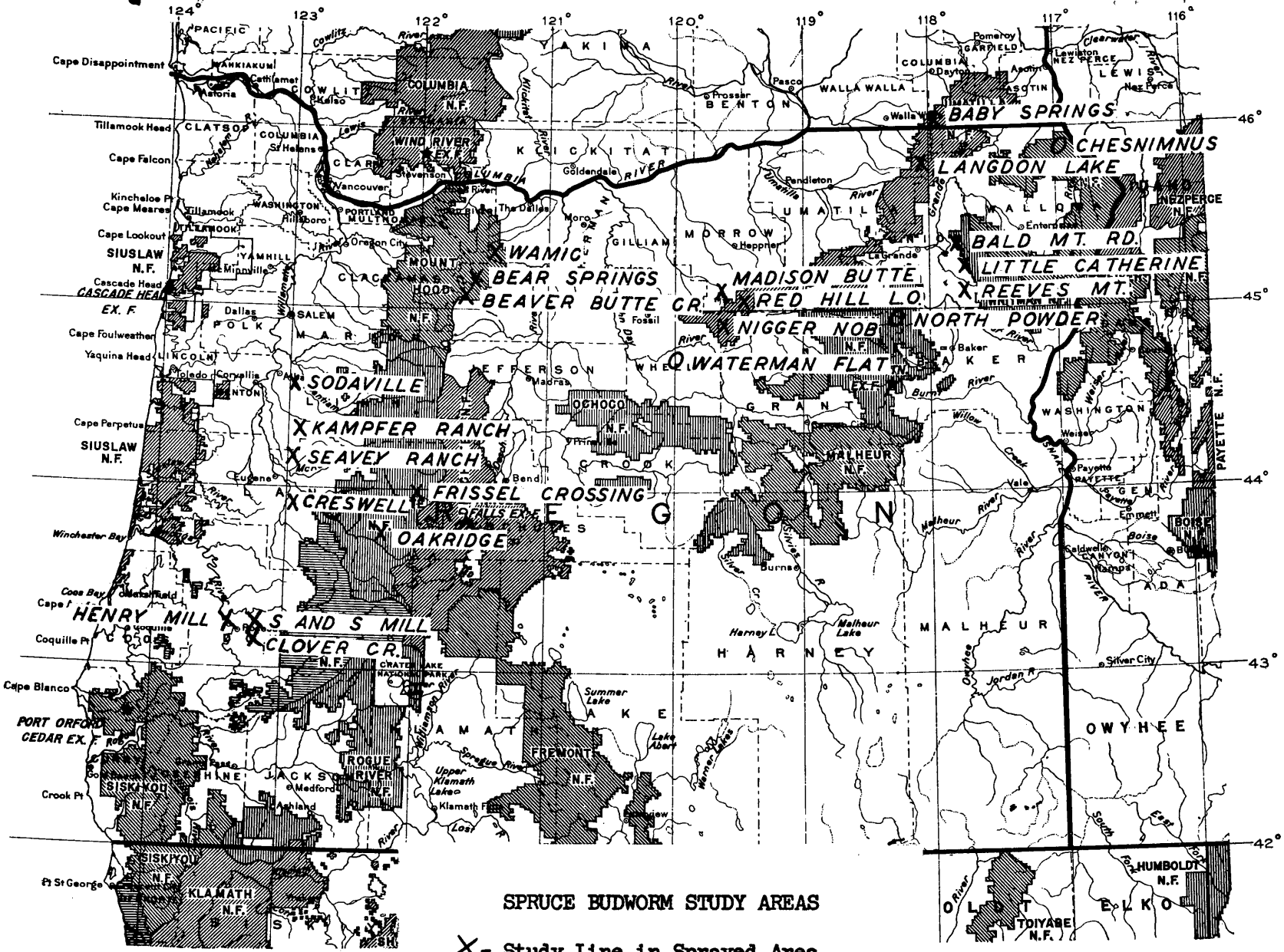
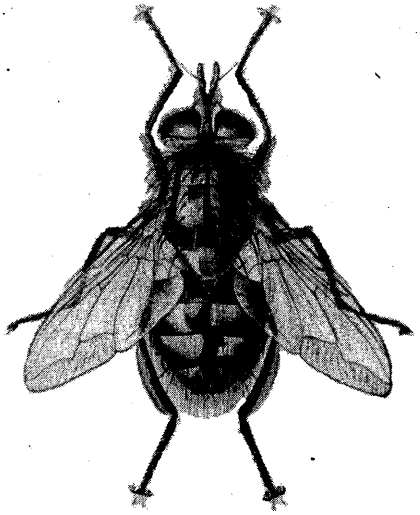
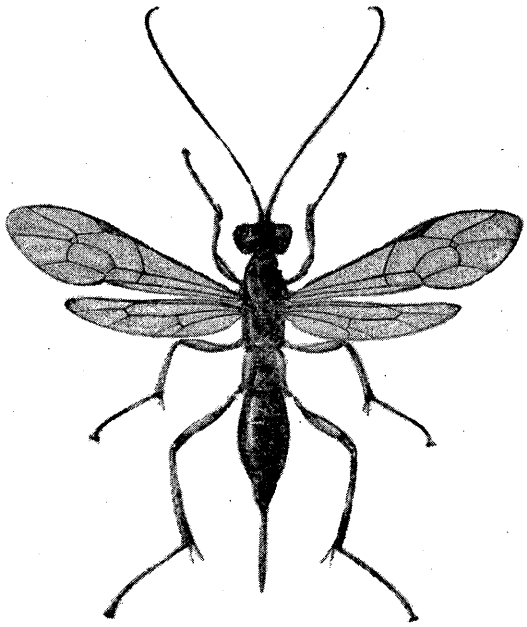

BABY SPRINGS
CHESNIMNUS
LANGDON LAKE
BALD MT. RD.
LITTLE CATHERINE
REEVES MT.
NORTH POWDER
MADISON BUTTE
RED HILL LO.
NIGGER NOB
WATERMAN FLAT
WAMIC
BEAR SPRINGS
BEAVER BUTTE CR.
SODAVILLE
KAMPFER RANCH
SEAVEY RANCH
FRISSEL CROSSING
CRESWELL
OAKRIDGE
HENRY MILL
S AND S MILL
CLOVER CR.
PORT ORFORD CEDAR EX. F.
SPRUCE BUDWORM STUDY AREAS
X- Study Line in Sprayed Area
O - Study Line in Unsprayed Area
MILES
0 50 100
1939
BASE BY U.S.G.S.

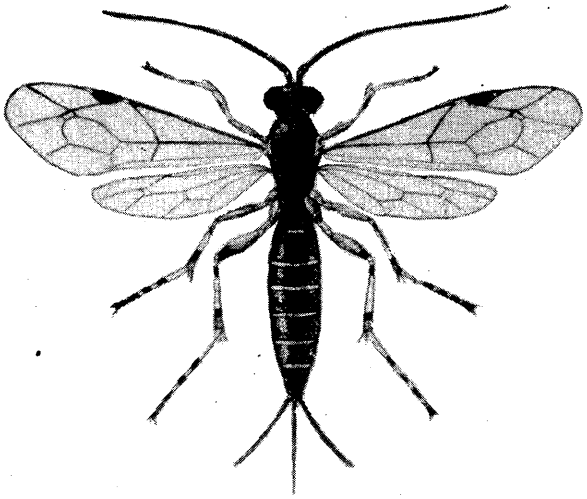
PLATE II





PARASITES ATTACKING MATURE LARVAE

Fig. 4. Omotoma fumiferanae (Toth.) Fig. 5. Phytodietus fumiferanae Rohw.



PARASITE ATTACKING PUPAE

Fig. 6. Itoplectis obesus (Cush.)

(Illustrations Greatly Enlarged)

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